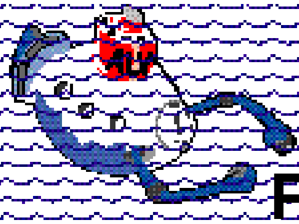


Finding the Way

Focus
Underwater Navigation

Grade Level
9-12

Focus Question
What types of navigational tools are used in deep sea explorations?

Learning Objectives
Students will describe the compass, Global Positioning System (GPS), and sonar and their use in underwater exploration.

Students will understand how navigational tools can be used to determine position and navigate underwater.

Adaptations for Deaf Students
None required

Materials
- ❒ Pencil
- ❒ Protractor
- ❒ String (12")
- ❒ Copies of maps for Legs 1, 2, and 3 (copies for students)
- ❒ Diagram of ALVIN (for overhead or copies for students)
- ❒ Clay (to holdfast pencil and submersible)
- ❒ Copy of maps for Legs 1, 2, and 3
- ❒ Graph paper (to list coordinates from "leg" map)
- ❒ Compass
- ❒ Hand-held Global Positioning System (GPS) (if available)

Audio / Visual Equipment
Overhead projector

Teaching Time
Two 45-minute periods

Seating Arrangement
Pairs of students

Key Words
Sonar
GPS
Submersible
Navigation
Compass
Latitude
Longitude
Slant range positioning
Calibrate
Dynamic positioning
Hydrophone
Multibeam side scanning sonar
Ping
Transducer (track point)
Altitude
Prime meridian

Background Information
In history, humans have relied on many ways to navigate the globe. In many ways, explorers still rely on signs from the water, air, and sky through observations of currents, the stars, wind patterns, and the sun. Navigation is the way of charting a course and the methods used to find the way to a specific location.

One of the simple tools we use to locate direction is a compass. For wherever you stand on Earth, the needle on the compass will point toward the Earth's pole. The needle, which is a small metal magnet on a frictionless pivot point, is attracted to the magnetic pull from the planet's core. Explorers use this instrument to guide them in navigating above and underwater. Even if there is little visibility due to fog or dark waters, a compass can lead the way.

The introduction of radio beacons in 1921 provided the first electronic aid to navigation. Some 50 years later, the U.S. government began fashioning a revolutionary satellite system to coordinate the movement of planes, missiles, ships, and soldiers. Today this system is eclipsing traditional radio navigation. Known as the Global Positioning System (GPS), this manmade constellation of 24 satellites circles 11,000 miles above the Earth, hurtling through space on six separate orbits. Equipped with atomic clocks, computers receivers, and transmitters, these satellites continuously transmit radio signals giving their location and the time of day 1,000 times a second (K. Baker, 1997)*.

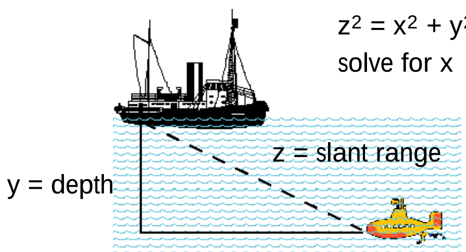
In locating a site on Earth, you need to determine the latitude and longitude of that position. The latitude is a measurement of distance in degrees north or south of the equator. The longitude is a measurement of distance in degrees east or west of the prime meridian, or the imaginary line that runs through the geographic North Pole to the geographic South Pole passing through Greenwich, England.

By measuring the time it takes to receive each signal, a computerized receiver on Earth can determine its distance from the satellite. By comparing the radio signals from at least three satellites, a GPS receiver can determine its exact location—latitude, longitude and altitude—24 hours a day, around the globe. At least four satellites can be accessed from any location at any time. Put into orbit and maintained by the U.S. Department of Defense, the system is freely available to users throughout the world (K. Baker, 1997)*.

Since the GPS does not function for underwater navigation, researchers use sonar to locate a position underwater. Sonar is a method of using sound waves, which are emitted from a transducer or track point. For example, a boat on the water's surface can send out a "ping" or sound wave from its transducer aboard ship.

The waves will be received by a transducer aboard a submersible, which will respond by sending out sound waves that will be received by the boat's track point. In this way, the boat will be able to locate the position of the submersible or underwater manned research vehicle, as it navigates to a site. The track point, however, can actively broadcast a signal at a particular frequency as well as receive a ping. A hydrophone is passive sonar equipment that can only receive or listen to sound.

Using sonar, the depth of the ocean from the bottom of the boat can be measured. Knowing the latitude and longitude of the boat by using the GPS, the depth slant range using sonar, and compass direction of the submersible from the boat, you can determine the position of the submersible as it navigates the waters. As the submersible sends out its ping and the boat responds, this gives an acoustical line of sound called slant range positioning. With this information, a scientist can calibrate, or measure, the exact position of the submersible under the water.



Of particular interest to the commercial diving or underwater contractor are subsea applications that include construction support, route surveys, seafloor mapping, seismic surveys, and automated positioning surveys for exploring rigs, ships, and platforms. Positioning technology enables remotely-operated vehicles (ROVs) to better perform services including construction support and intervention, drill rig support, platform and pipeline inspection, and site cleanup (K. Baker, 1997)*. For a ship to maintain its position on the surface of the water, automated technology allows for the movement or “set and drift,” thereby enabling the vessel to stay in one place. This is termed dynamic positioning. Subsea applications, which occur often during the night before the expedition, will include a multibeam side scanning sonar used in preparation to map the study site.

Scientists on board the Deep East 2001 Voyage of Discovery will be using a variety of navigational equipment in the field. For example, on Leg 1 (George’s Bank Canyons), navigational equipment will assist Dr. Les Watling from the University of Maine and his science team on an expedition to locate deepwater corals in the canyons south of Georges Bank. The rarity of encounters with octocorals during recent submersible dives across the shelf of the northeast U.S. suggests that the distribution of these species—which are critical habitat for commercial fish species—has significantly declined in the past three decades.

The Hudson Submarine Canyon, an ancient extension of the Hudson River Valley, extends over 400 nautical miles seaward from the New York-New Jersey Harbor across the continental margin to the deep ocean basin. Past investigations show that the Canyon area has potential for discovery of unusual deep-sea organisms. Near this location is the deep-sea sewage sludge dumpsite known as DWD-106. The National Oceanic and Atmospheric Administration (NOAA) has used ALVIN in this area to investigate the site. Dr. Fred Grassle from Rutgers University and his science team will also use navigational technology to study gas hydrates, and explore the exotic communities associated with methane venting during Leg 2 of the Deep East Voyage of Discovery.

Located off the southeastern U.S., the Blake Ridge contains cold seep communities, including chemosynthetic mussel beds and bacteria. These communities mark underlying gas and oil resources. The Deep East 2001 Voyage of Discovery is the first-ever submersible exploration of a cold seep chemosynthetic community of the U.S. east coast. Dr. Cindy Van Dover, from the College of William and Mary, and her science team will use navigational technology to investigate this newly-discovered cold seep communities during Leg 3 of the Deep East Voyage of Discovery.

* "Navigation & Positioning Systems: Finding Your Way Through Today's Offerings", by Karen Baker (UnderWater Magazine, 1997) www.diveweb.com/uw/archives/arch/uw-wi97.02.htm

Learning Procedure

1. Define navigation and make a list with the students about different methods of finding the way. (Answers may include the sun, stars, ocean currents, or compass).
2. Using the compass, demonstrate how the needle always points north.
3. Discuss modern methods of navigation describing GPS and sonar.
4. Show the diagram of ALVIN and identify the sonar.
5. Describe the many ways navigational tools assist in underwater research.
6. Give each pair of students one copy of the Student Instruction Sheet and one copy of either Map #1, #2, or #3.
7. Explain to the students that one of the main goals of Leg 1 is to locate and characterize deepwater octocoral communities of the Georges Bank Canyons and on Bear Seamount. The goals of Leg 2 are to study the DWD-106 mile dumpsite on the continental rise east of New Jersey and investigate the occurrence of exotic communities at hydrate beds, as well as methane venting from the beds. The main focus of Leg 3 is to study the mussel beds along the gas hydrate cold seep site. This site is the first cold seep located along the U.S. coast.
8. Explain to the students that in underwater research, the research vessel will use sonar to locate the position of the submersible as it navigates to the study site. Navigational logs and records containing coordinates are kept so they can be used to assist in future studies. In this way, study sites can be revisited.

The BRIDGE Connection

Use the BRIDGE for related lessons at www.marine-ed.org

The "Me" Connection

Ask students to investigate older technologies used in previous ocean exploration initiatives and to infer how new ocean exploration technologies might affect their own lives 10, 20, and 30 years from now.

Connection to Other Subjects

Mathematics, English/Language Arts

Evaluation

Use the following questions to guide a discussion about what was learned during this activity:

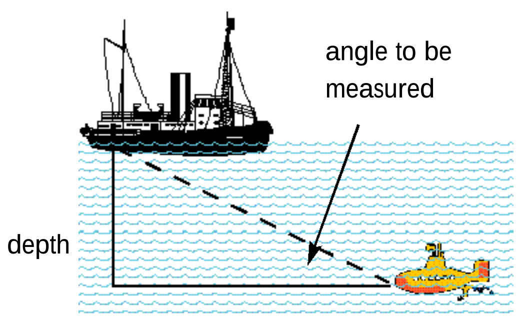
- What instruments can be used in navigation?
- What navigational tool cannot be used under water?
- How can sonar be used to navigate under water?
- How can a research scientist use technology to locate a previously-studied site?
- Ask students to write a synopsis on underwater navigation and how this knowledge might make a difference in their lives 10 years from now.

Extension

Using a protractor, measure the angle of the slant range (making the hypotenuse of a triangle). Using the Pythagorean Theorem or Law of Sines, calculate the actual range from the boat to the submersible.

Pythagorean Theorem: $A^2 + B^2 = C^2$

Law of Sines:
area = 1/2 ac sine B   area = 1/2 ab sine C



- Visit the NOAA Ocean Explorer web site for more information on Deep East at http://ocean-explorer.noaa.gov/
- Visit How Compasses Work at www.howstuffworks.com/compass.htm
- Visit NASA-ERC at www.pitt.edu/`nasa/learninglab/Act_001.html
- Visit EDO Navigation Systems at www.edocorp.com/indust/acoustic/products/navprod.html
- Visit Study Web at www.studyweb.com/links/4450.html
- Visit USNS Pathfinder Question & Answer Page at http://voyager.snc.edu/Ocean/pathfinderqanda.html%20

National Science Education Standards:

Content Standard A – Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B - Physical Science
- Motions and forces
- Interactions of energy and matter

Content Standard C – Life Science
- Interdependence of organisms

Content Standard D – Earth and Space Science
- Energy in the Earth system

Content Standard E – Science and Technology
- Abilities of technological design
- Understandings about science and technology

Content Standard F – Science in Personal and Social Perspectives
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national and global challenges

Content Standard G – History and Nature of Science
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

Student Instruction Sheet

Procedures:

In order to find ALVIN, the mother ship will send out a sonic ping. ALVIN has a transponder on it that receives the ping and sends a ping back to the mother ship. Knowing the time of this relay and speed of sound in water allows the ship to know the “slant range” to the submersible. This information along with the position of the ship and depth below the ship allows us to find the position of the submersible. This activity will allow students to create a submersible track based on the bearing and slant range data.

Choose a “Leg” chart and perform following steps:

1. Mark a ship and dive site location on the chart and record coordinates
2. Place a pencil on ship location and tie a string 8 - 10 units up on pencil—this gives a depth (y in Figure 1) of 8-10 units.
3. Pick a bearing (angle from ship measured from 0 degrees due North, i.e., straight up on chart; see Figure 2) and draw line from the ship.
4. Pick a slant range (z on Figure 1) that will place the submersible on the chart along the bearing line; hold fingers on the string at the number of units chosen.
5. Place fingers on line and mark position of submersible. Record coordinates which are position of the submersible.
6. Calculate the actual distance from the ship to the submersible (x on Figure 1) using x = (z2-y2)1/2
7. Determine what direction and distance the submersible should go to get to the dive site
8. Repeat activity with a list of new bearings and slant ranges.

Figure 1

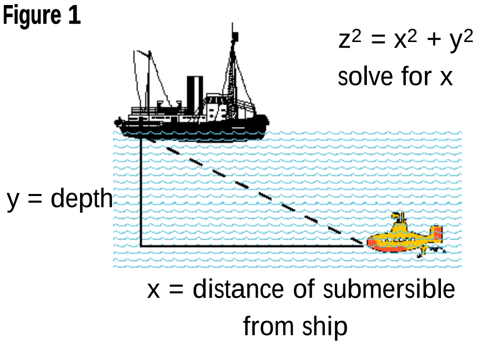
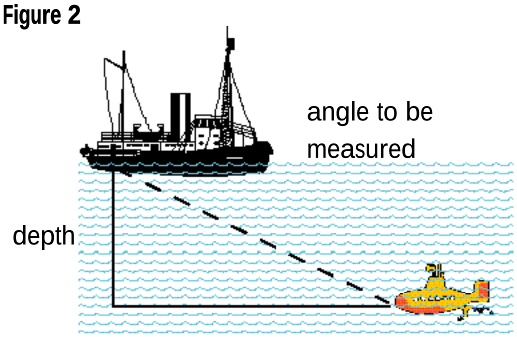
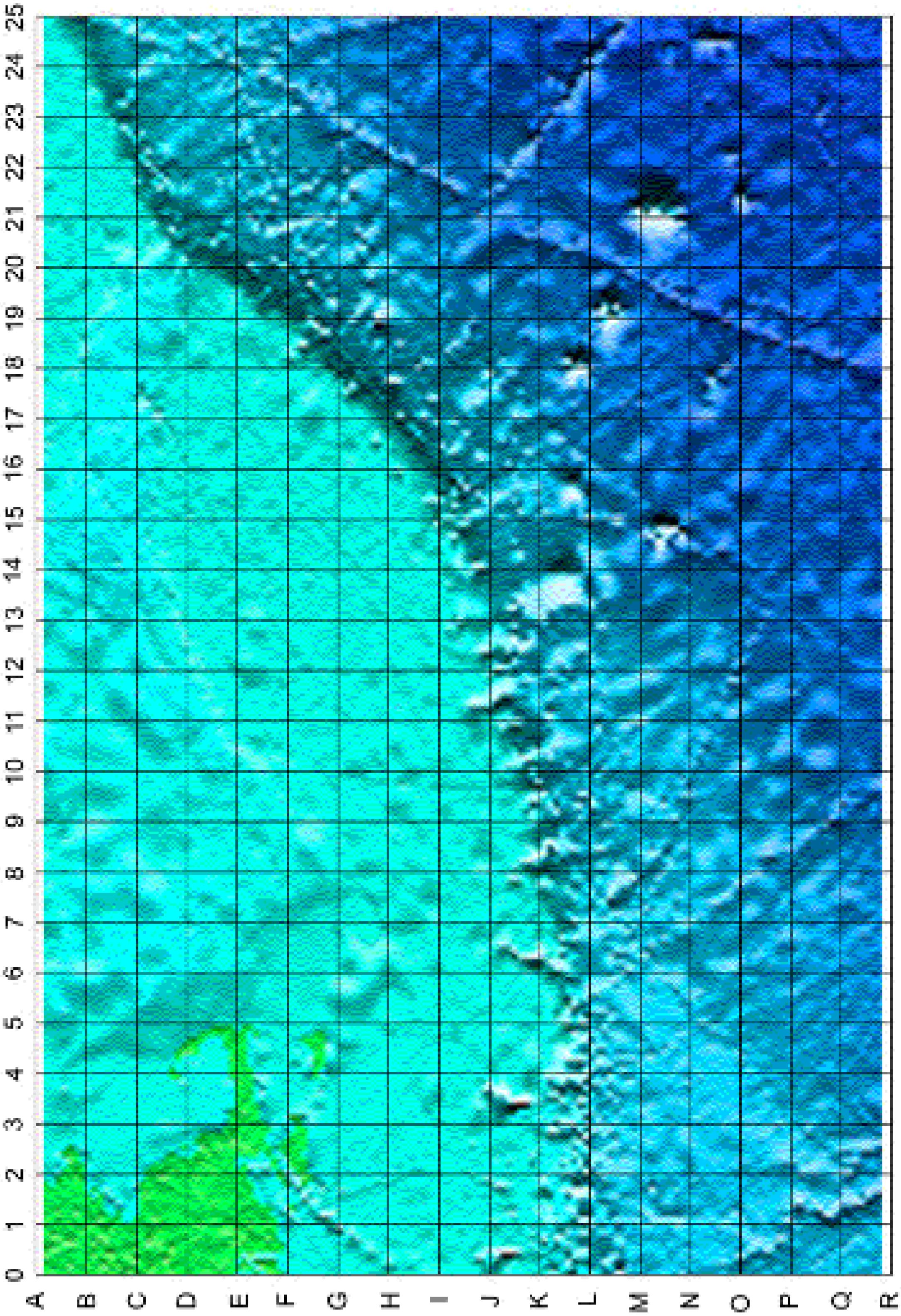
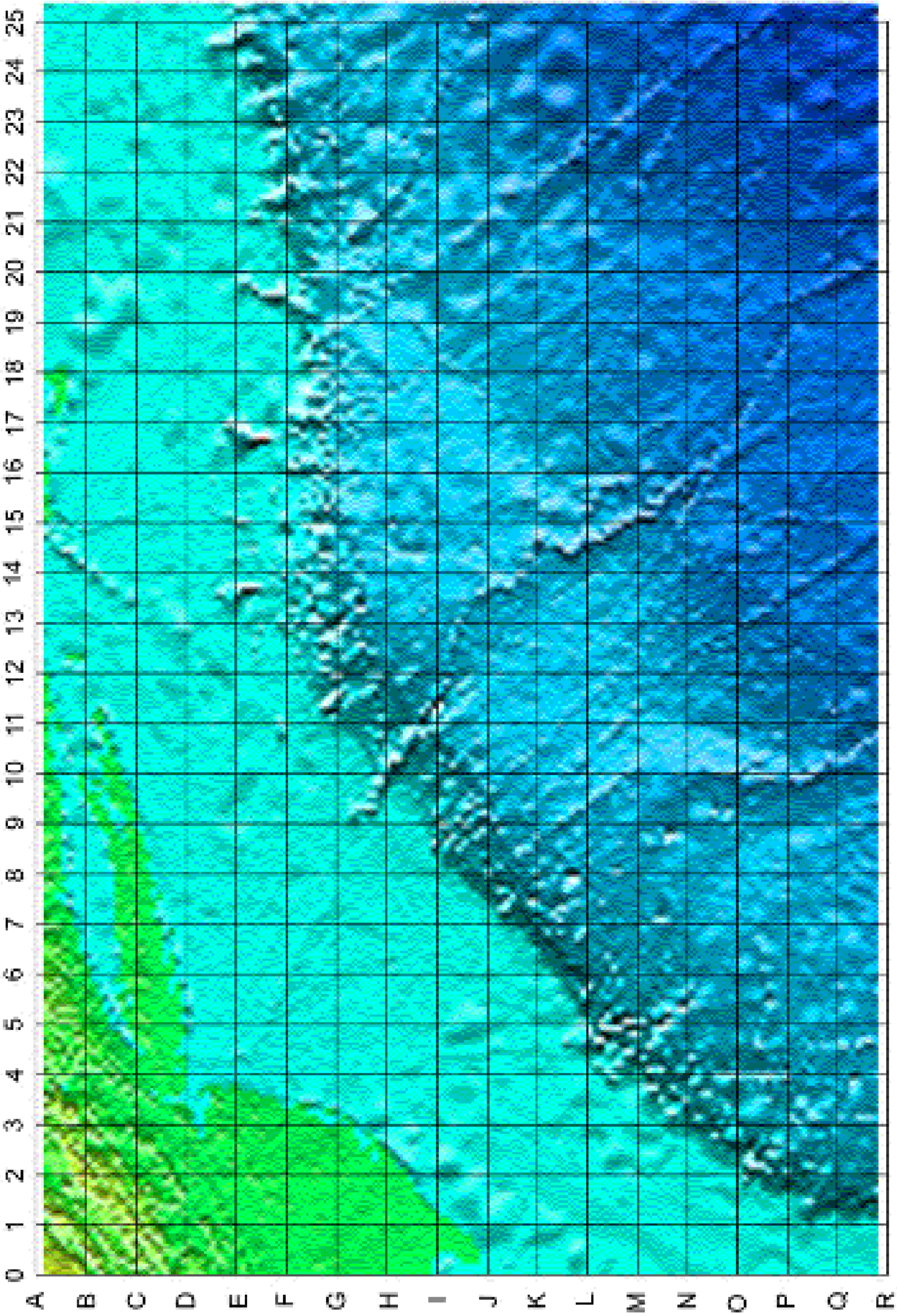


Figure 2

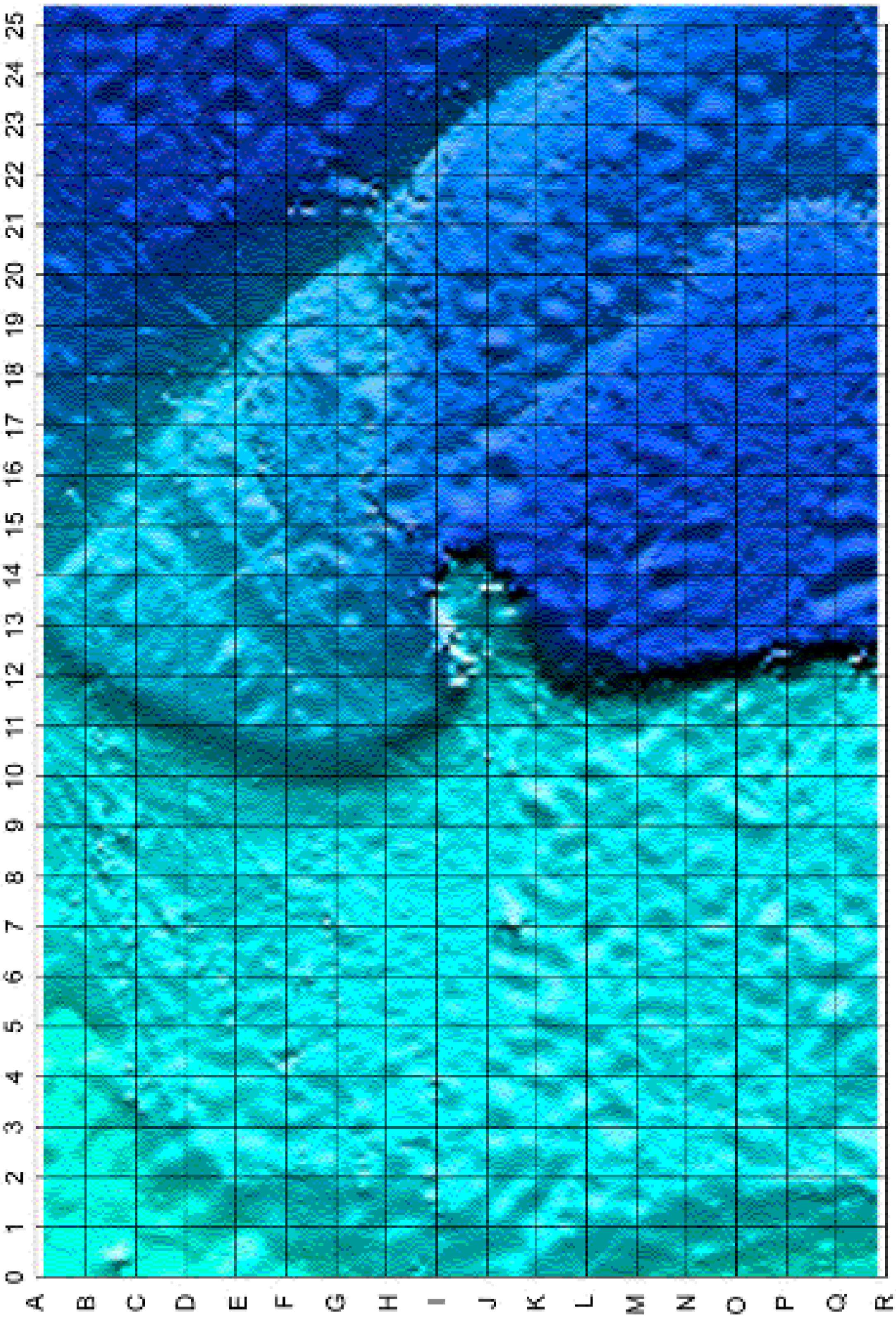




Map of Leg #1, Georges Bank Canyon



Map of Leg #2, Hudson Submarine Canyon



Map of Leg #3, Blake Ridge

Notes/Thoughts/Inspirations